Title: Linear Functions--Exploring the Relationship Between Running and Walking

Brief Overview:

When we want to know how fast or slow anything moves, we measure its speed - the total path a moving object travels per unit or time. In this learning unit, students will gain an understanding of how to measure the constant speed of runners at different time intervals. Students will also work in cooperative groups to collect, record, analyze, and display data on record sheets.

Links to NCTM Standards:

- **Mathematics as Problem Solving**
  Students will demonstrate their ability to work cooperatively in groups to graphically display data collected and analyzed on the speed and motion of runners.

- **Mathematics as Communication**
  Students will demonstrate their ability to communicate mathematical ideas both orally and in writing.

- **Mathematics as Reasoning**
  Students will demonstrate their ability to use critical thinking skills by writing a linear equation using real-world data and applications in solving problems.

- **Mathematical Connections**
  Students will demonstrate their ability to investigate connections between linear functions and real-world mathematical applications.

- **Patterns and Functions**
  Students will demonstrate their ability to develop tables, graphs, charts and rules to present collected data.

- **Algebra**
  Students will demonstrate their ability to develop an understanding of variables, expressions and equations.

- **Measurement**
  Students will demonstrate their ability to make estimations and predictions by using measurement to solve speed and motion problems.

Links to Science Standards:

- **Physical Science**
  Students should develop an understanding of how measurement is important in all scientific endeavors.

- **Unifying Concepts and Processes in Science**
  Students should develop an understanding of how fast or slow anything moves.

- **Science and Technology**
  Students should develop an understanding of how to use the hand-held graphing calculator (TI-83) to evaluate and to solve science problems.

Grade/Level:

Gifted middle school students to grade 12.

Duration/Length:

Two class periods.

Prerequisite Knowledge:

Students should have a working knowledge of the following skills :

- Collecting, analyzing and interpreting data
- Finding the equation of a line on TI- 82/83
- Finding the equation of a line
- Using the slope and y - intercept
- Applying the properties of functions

Objectives:

Students will:

- sketch the graph of functions.
- graph rational functions.
- record speed and motion at intervals.
- compute averages.
- write linear equations.
- apply the properties of functions.

Materials/Resources/Printed Materials:

- Masking tape
- Scissors
- Yard stick
- Stop watch
- Transparency of recording sheet
- Transparency pen
- Overhead projector/cord
- Student activity recording sheets
- Graph paper
- Magic markers
- Pencils
- TI-82/83 Graphic Calculators
- Rulers

Development/Procedures:

This is a cooperative learning approach which makes use of the following procedures:

1. The students are divided into groups of approximately 5 students each. There are 3 runners, 1 timer and 1 recorder.
2. An area in the classroom, at least 50 feet long, with a smooth surface will be selected to be used as a race track.

3. The recorder will measure the constant speed of the first 3 runners at evenly spaced intervals along a straight way.
4. The recorder will collect data (amount of time in seconds it takes a runner to pass the timer at evenly spaced intervals) and record the data on the transparency recording sheets.
5. The timer will start the stopwatch when the starter says start.
6. The runners will run 5 times (3 runs at a constant rate and 2 at a very fast rate).
7. On Handout, "Recording Sheet" the recorder will record the average of the first runner.
8. The recorder will continue to compute the speed of the other 2 runners and than record this information. Comparisons will be made by the computation of speed averages.

Performance Assessment:

Each student will be evaluated to ascertain the correctness of data collection, graphs, and questions answered by each group. Rubric scoring will be used with this learning unit (see Activity 4). A numerical value from 0 to 4 will be assigned to each item. A point of 0 will be given for incorrect answers. A point of 1 will mean novice, a point of 2 will mean apprentice, a point of 3 will mean proficient, and a point of 4 will represent distinguished.

Extension/Follow Up:

- Groups may apply other variables to determine whether or not a linear relationship exists.
- Role reversal for comparative analysis.
- Groups will examine equations to determine which regression (power, exponential or logarithmic) is most appropriate to measure relationship.
- Students will use alternative motion (walk and then run) to determine if there is a linear relationship.

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ACTIVITY #1

GROUP INSTRUCTION SHEET

1. Students will work in groups consisting of five members.

2. Each group will have a recorder, timer, and starter.

3. The recorder will collect data and record the data on the recording sheets.

4. The timer will start the stop watch when the starter says start for the runner.

5. Each group will present results in written or oral report.

ACTIVITY #2

ANALYSIS WORKSHEET

Answer each of the following questions completely. Each graph must include labels and scales.

TRIAL ONE: CONSTANT SPEED (Run or Walk)

1. Sketch the graphs on the grids provided below.

#1 Runner

Time (sec)

Distance

#2 Runner

Time (sec)

Distance

#3 Runner

Time (sec)

Distance

2. How do you compute the average of each runner?

3. Look at the constant runs and determine the speed at each of the intervals for each runner.

ACTIVITY #2

ANALYSIS WORKSHEET (Continued)

TRIAL TWO: FASTEST SPEED (Run Only)

1. Sketch the graphs on grids provided below.

#4 Runner

Time (sec)

Distance

#5 Runner

Time (sec)

Distance

2. Look at the fast runs and determine the speed at each of the intervals. Which runner was the fastest?

3. Which interval was the runner's fastest?

4. What was the runner's average speed for the interval?

ACTIVITY #3

TECHNOLOGY SETUP PROCEDURE

I. Data Interpretation for Each Runner

1. Enter data for each runner into STAT list on the TI-83 graphing calculator. Enter x-values (time) into L1 and y-values (distance) into L2.

2. Setup the plot parameters:

- **Move the cursor to plot "on", then press ENTER.**
- **Move the cursor to "TYPE", then press ENTER.**
- **For "X LIST", press 2^{nd} L1.**
- **For "Y LIST", press 2^{nd} L2.**
- **For "MARK", use the 1^{st} entry (the box).**

3. Press ZOOM, then select #9 (ZOOM STAT) to graph your plot. Go to WINDOW and record below.

X min:_____ **Y min:_____**

X max:_____ **Y max:_____**

X scl:_____ **Y scl:_____**

4. Press STAT, go to CALC, and select #4 (LIN REG (ax + b)), then press ENTER. Record your values for a and b, rounded to five decimal places.

5. Press Y= and clear all equations, then press VARS and select #5 (statistics). Go to EQ and press ENTER. (This will put the calculators equation to your data into Y).

Calculator Equation _____ _____

For each runner _____ _____

_____

ACTIVITY #3

TECHNOLOGY SETUP PROCEDURE (Continued)

6. For each runner' graph, pick two points on the line and find the slope of the line. Use this to find the y-intercept and write an equation for the data.

Each runner's equation of the line of best fit: _____

_____

_____

_____

_____

7. Type runner's line of best fit into Y2. Press GRAPH and see if runner's line is the same as or close to the calculator's equation. If one of the runner's equations is significantly, different, give an explanation for the discrepancy.

Are they close? _____

8. On graph paper, each runner will sketch the calculators equation for the data. (Use the trace key to obtain accurate points).

RECORDING SHEET

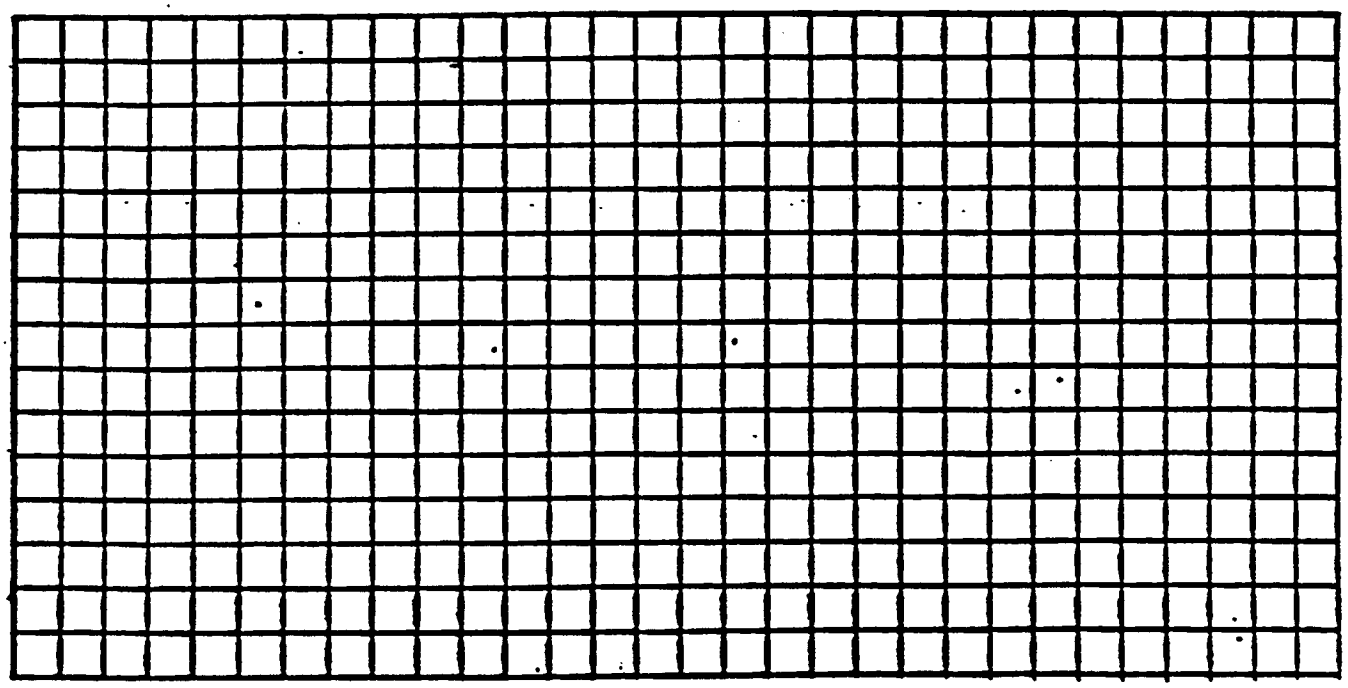
Runner_____

Times (in seconds)

	A	B	Average
10	_____	_____	_____
20	_____	_____	_____
30	_____	_____	_____
40	_____	_____	_____
50	_____	_____	_____

Graph:

_____



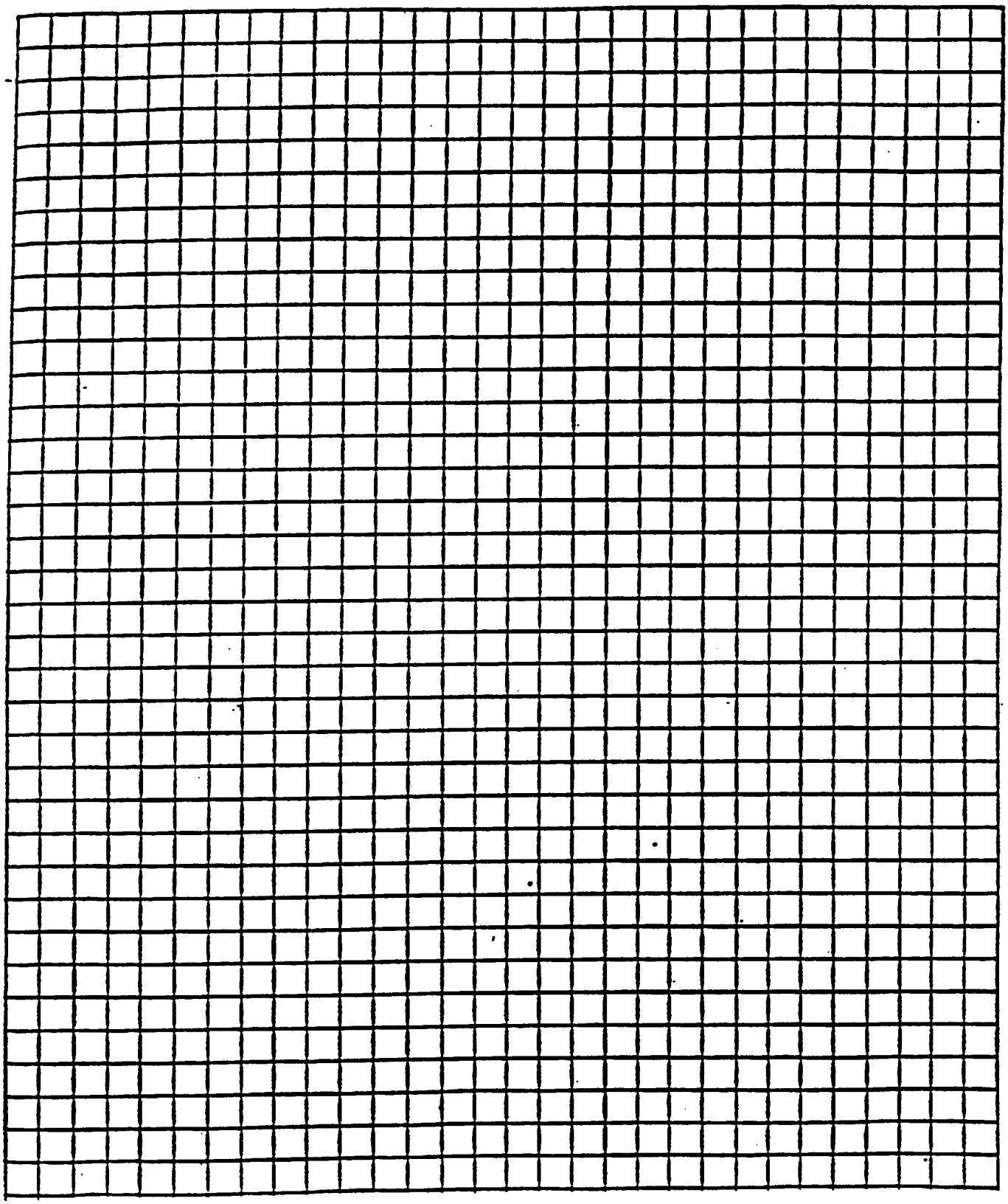
Was the speed constant?_____

NAME _____

Date _____

Section I ____ Section II ____

Make a graph of the third runner on the graph below.



ACTIVITY #4

RUBRIC EVALUATION

NAME: _____

PERIOD: _____

Each of the following items will be assigned a numerical value from zero to four. Examples of the range of each item are provided. Zero means task was not done. An average of four is distinguished, three is proficient, two is apprentice, one is novice.

DIMENSIONS OF THE EXPERIMENT

I. UNDERSTANDING THE PROBLEM

1. The reason for conducting the experiment is explained._____
2. Relevant information that is known is identified. _____
3. Interesting questions are asked relevant to the task. _____
4. Information that is needed is identified. _____

II. SOLVING THE PROBLEM

5. Data are used accurately. _____
6. Computations are completely accurate. _____
7. Variables are controlled. _____
8. Multiple trials are conducted. _____
9. Rounding or estimating are used appropriately. _____
10. Data are processed and analyzed. _____
11. Mathematically logical approach is evident. _____
12. From the experiment, generalized or extrapolated the data._____

III. GRAPHING THE PROBLEM

13. Plot all points correctly. _____
14. Draw the line or curve accurately. _____
15. Label the line or curve with the rule (an equation, Y=)_____
16. Develop an accurate and appropriate scale. _____
17. Label X and Y axes. _____
18. State coordinates of points in (X,Y) form. _____
19. Label X and Y-intercepts. _____

ACTIVITY #4

RUBRIC EVALUATION (Continued)

IV. COMMUNICATING THE RESULTS

20. The written explanation is easy to follow. _____

21. The written explanation contains enough of the math to satisfy the reader that the answer is well supported. _____

22. Graphs, charts, tables, drawings or other graphs are used to support the written explanation. _____

23. Mechanics of English are correct. _____

24. The work is neat and presentable. _____